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Nonlocality – A review
of some Recent Work

Cambridge 1984
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Nonlocality — A Review of Some Recent Work

Cambridge, Feb. 1984

(Reply to Paul Teller

Warwick, Sept. 1984)

THREE VIEWS ON OBSERVABLES NOT IN AN EIGENSTATE.

A) Sharp unknown value

B) Unsharp or 'Fuzzy' Value

C) Undefined or 'meaningless' value

WHAT DOES MEASUREMENT DO?

A) Pre-existing value revealed

B) Potential or Latent value actualized

C) Undefined value becomes defined

HOW IS THIS CHANGE BROUGHT ABOUT?

1) Interaction with a physical system

2.) Action of human Consciousness

THE KOCHEN-SPECKER RESULT

Sharp Values + (FUNC)

$\Longrightarrow$ Contradiction

FUNC: If $\hat{A}$ and $\hat{B}$ are s.a. operators s.t. $\hat{A} = f(\hat{B})$

Then $[A]^{\phi} = f([B]^{\phi})$

i.e. $[f(B)]^{\phi} = f([B]^{\phi})$

FUNCTIONAL COMPOSITION PRINCIPLE

$$[f(O)] = f([O])$$

This implies the SUM RULE:

gf A, B commute

$$[A+B] = [A] + [B]$$

$[f(O)]^{|\phi\rangle}_{\mathcal{L}}$ denotes result of measuring $f(O)$ in conjunction with a set of commuting observables $\mathcal{L}$, in state $|\phi\rangle$.

We query

$$[f(O)]^{|\phi\rangle}_{\mathcal{L}} = [f(O)]^{|\phi\rangle}_{O} \underset{Df}{=} f([O]^{|\phi\rangle})\ ?$$

ANGULAR MOMENTUM IN QM

$$[J^2] = [J_x^2 + J_y^2 + J_z^2] = \ell(\ell+1)\hbar^2$$

ℓ is any integer or half-integer

$[J_x], [J_y], [J_z]$ take any values from $-\ell\hbar$ to $+\ell\hbar$ in integral steps

($\hbar \sim 10^{-34}$ Joule-seconds)

Exs $\ell = \frac{1}{2}$, $[J] = \frac{\sqrt{3}}{2}\hbar$, $[J_z] = \pm\frac{1}{2}\hbar$

$\ell = 1$, $[J] = \sqrt{2}\hbar$, $[J_z] = -\hbar, 0$ or $+\hbar$.

THE KOCHEN-SPECKER PARADOX

For $\ell = 1$

$$[J_x^2] + [J_y^2] + [J_z^2] = 2$$

But each value is 0 or 1

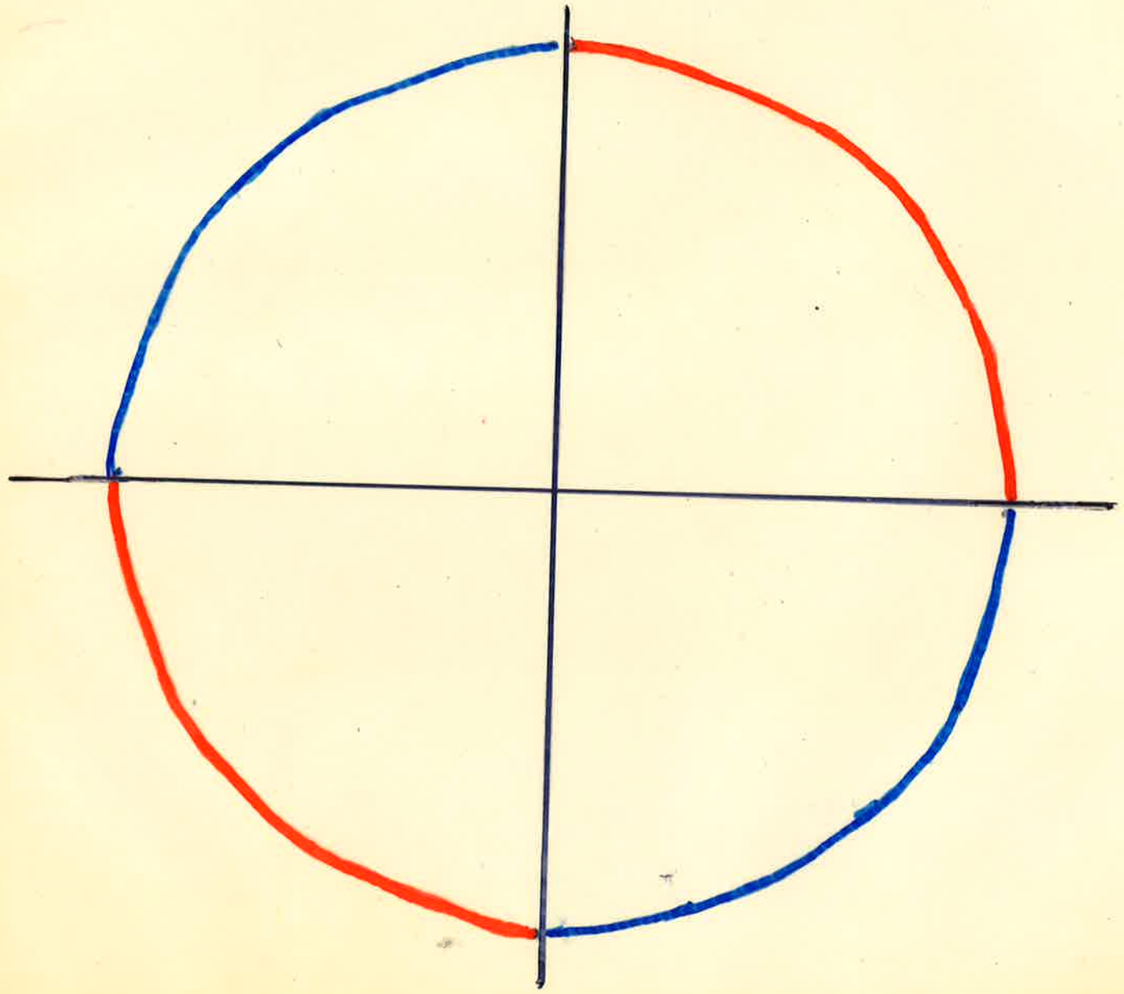
$\therefore$ 2 out of $[J_x^2], [J_y^2], [J_z^2]$ Must have Value 1

Remaining one must have Value 0.

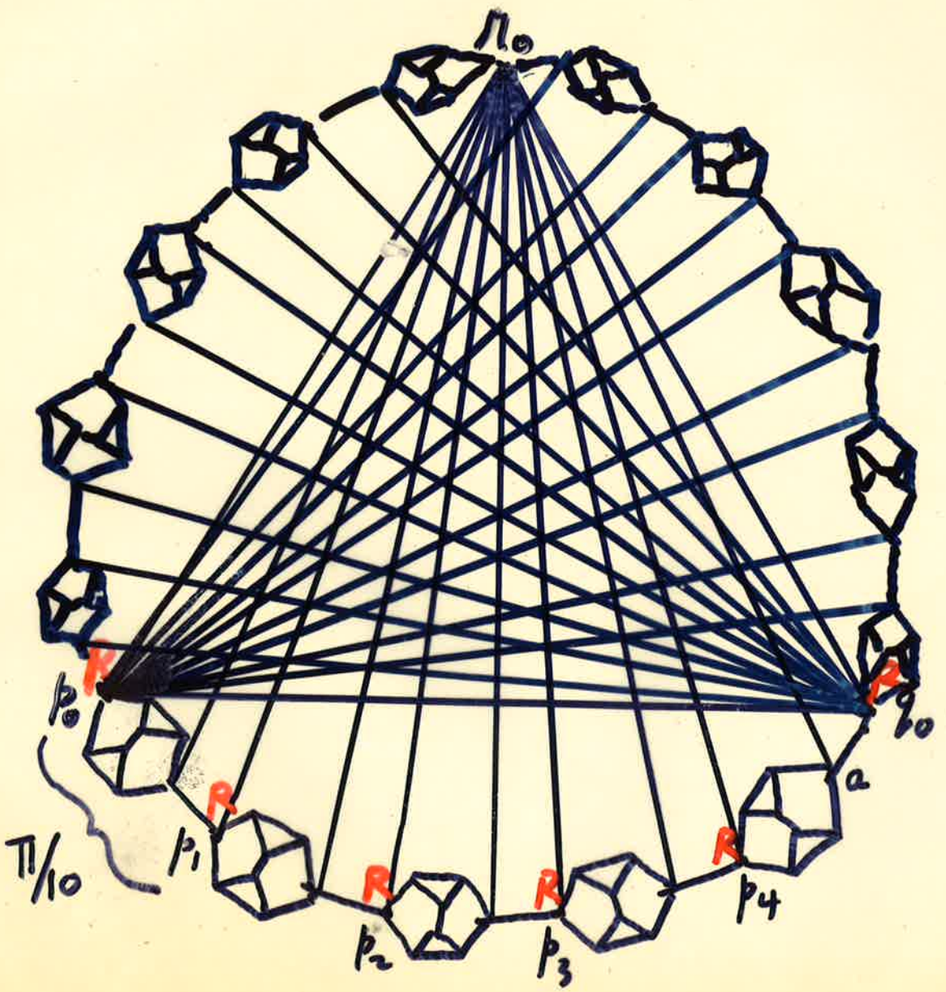
THE TWO-COLOUR THEOREM

On the surface of a sphere it is not possible to colour every point either red or blue, so that for every orthogonal triad of directions only one is coloured red

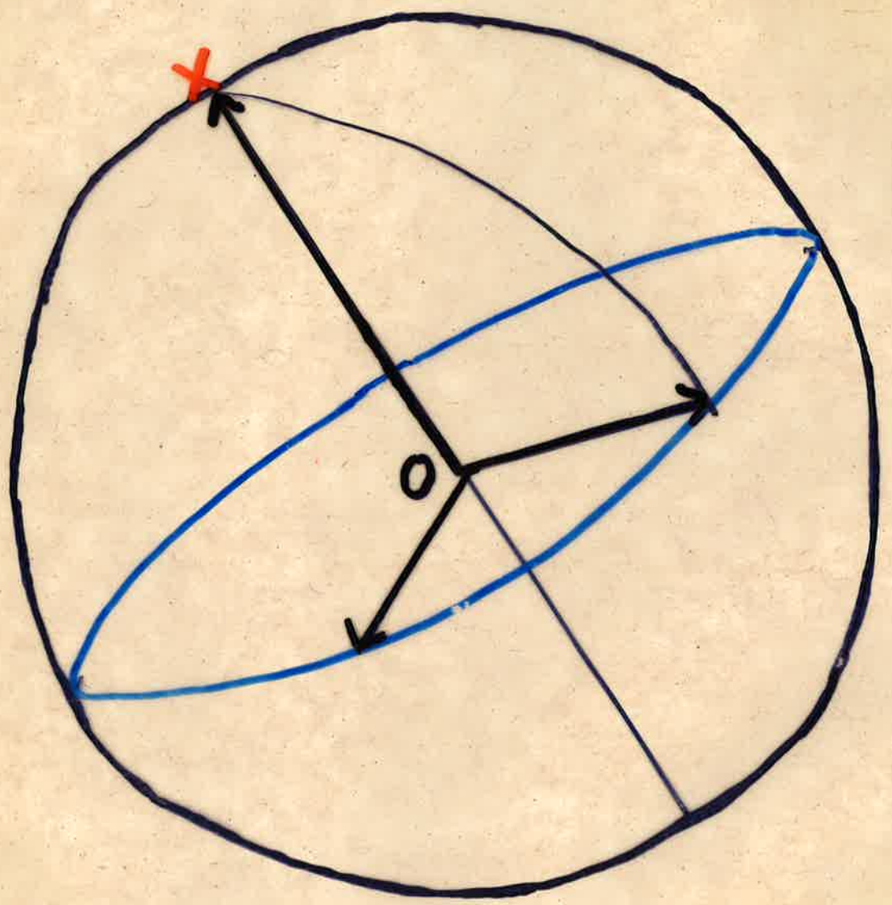
Two-Colour Theorem in Two Dimensions



KOCHEN-SPECKER PROOF OF TWO-COLOUR THEOREM IN THREE DIMENSIONS



BELINFANTE'S PROOF OF THE TWO-COLOUR THEOREM.



DEDUCKHAM ISATION

Distinguish A_B and A_C

where $A_B \overset{\phi}{=} t([B]_\phi)$

$([D]\rho) \in A_C \overset{\phi}{=} [A_C]$

ENHC$_*$: $A_B = A_C$ if $\hat{B} * \hat{C}$ commute

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so $[A]_\phi = t([B]_\phi) = ([D]\rho) \in A_C$

$0 \neq [\hat{C}, \hat{B}]$

$([C]\rho) = \hat{A}$, $(\hat{B})\, q = \hat{B}$

Find possible values for 2-X

no zigzag loop

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PROOF OF FUNC

Sharp Values (A) + Corr. + R ⇒ FUNC

So (¬A) ∨ (¬Corr.) ∨ (¬R)

↓ Bell

↓ Van Fraassen

↓ Fine

Consider the quantity $[A_B]^\phi$.

Suffix B explicates
Ontological Contextuality

But the value $[A_B]^\phi$ may also depend on the environment, in particular an apparatus set to measure some Maximal magnitude C.
So we write $[A_B]^\phi(C)$

The parameter C explicates
Environmental Contextuality

LOCALITY PRINCIPLES

OLOC: Locally maximal physical magnitudes on either of two spatially separated systems are not 'split' by ontological contextuality relative to the specification of different maximal physical magnitudes for the joint system.

ELOC: The value possessed by a local physical magnitude cannot be changed by altering the arrangement of a remote piece of apparatus which forms part of the measurement context for the combined system.

THE REDHEAD - HEYWOOD RESULT

FUNC* & VR & ELOC & OLOC $\Rightarrow$ Contradiction

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where VR is the Value Rule:

$$\Gamma_Q^{\phi}(\lambda) = 0 \Rightarrow [Q]^{\phi} \neq \lambda$$